THE STORM WATER MANAGEMENT MODEL (SWMM) AND RELATED WATERSHED TOOLS DEVELOPMENT

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LTG 3 Poster 01

Science Questions

MYP Science Question:

What additions to models are most needed for the TMDL process? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?

Research Questions:

• How can we improve existing urban wet weather runoff and combined sewer overflow models to make them more robust and easier to deploy in TMDL, CSO, and SSO studies?

• How can structural and non-structural BMP/LID stormwater management controls be effectively incorporated into urban runoff models?

• Which management alternatives will achieve water quality objectives at the lowest cost?

How Research Addresses the Water Quality MYP Goals

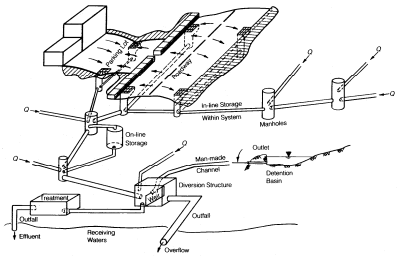
SWMM is a primary technical transfer tool for NRMRL's research on managing wet weather flows and nonpoint sources within urban watersheds. It is frequently a key component used in TMDL determinations, NPDES stormwater permitting, CSO/SSO mitigation studies, and sewer system capacity assessments under CMOM. Continued support and enhancement of SWMM helps to insure that the regulated community is supplied with the high quality computing tools it needs to make defensible quantitative assessments of alternative pollution control strategies for protecting and restoring impacted aquatic systems.

Research Objectives

The Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, natural channels, storage/treatment devices, pumps, and regulators.

SWMM can be used in both highly urbanized areas and in fast-developing urban fringe areas to:

- **size detention facilities for flood control and water quality protection**
- **design control strategies for minimizing combined sewer overflows**
- **evaluate the impact of inflow and infiltration on sanitary sewer overflows**
- **generate non-point source pollutant loadings for waste load allocation studies**
- **evaluate the effectiveness of BMPs for reducing wet weather pollutants.**



SWMM is the only publicly available model capable of performing a comprehensive analysis of wet weather loadings and control options for urban and developing watersheds of various sizes. Developed by EPA some 30 years ago and updated only intermittently since then, SWMM had become increasingly difficult to use and extend in today's current desktop computing environment.

To revitalize this valuable wet weather modeling tool, EPA-NRMRL partnered with CDM Inc. through a Cooperative Research and Development Agreement to produce a complete rewrite of the SWMM model. The goals of this project were:

- **to rewrite SWMM's engine using an objected-oriented approach**
- **to provide SWMM with a graphical user interface**
- **to develop a converter program to convert old SWMM data sets into the new format**
- **to improve key computational aspects of the program**
- **to develop guidelines for implementing BMP/LID modeling with SWMM.**

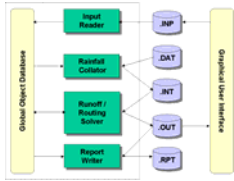
Research Methods & Collaboration

The SWMM redevelopment project was implemented using modern software engineering methods. These included developing a requirements assessment and a detailed project plan, utilizing rapid prototyping where appropriate, performing both unit and regression testing for quality assurance, and eliciting user feedback over several beta releases. In addition, an Experts Advisory Panel was established to provide project oversight.

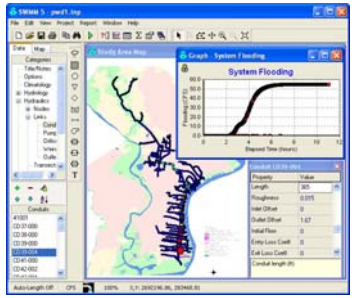
In working collaboratively with CDM, EPA was responsible for all software engineering and programming of SWMM itself while CDM developed the separate converter program for legacy data sets. Both parties contributed to algorithm improvements and to quality assurance testing.

Research Results

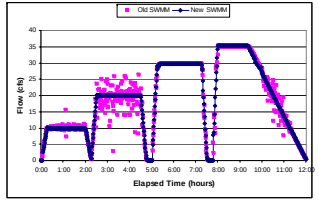
• SWMM's engine was completely re-written in object-based C. The old SWMM's separate computational modules (e.g., Rainfall, Runoff, Transport, Storage/Treatment) were integrated together into a more unified and cohesive system. The code's structure was greatly improved and extensive commenting was used throughout which will make future updates and improvements much easier.



• A full-featured Graphical User Interface was developed. It greatly simplifies the process of constructing a SWMM model from an actual catchment area and allows users to easily explore various what-if scenarios that effect runoff and CSO quantity and quality.



• A Quality Assurance Testing report was produced that demonstrated numerical improvements of new SWMM versus old SWMM. The flow hydrograph on the right illustrates the reduction in numerical instability achieved by the new SWMM in just one of the 20 test data sets that were analyzed. Improvements were also made to the runoff, groundwater, real-time sewer control, and treatment functions within SWMM.



• A new SWMM web site was created to distribute the SWMM program, its documentation and all of its source code. The site is continually updated as newly discovered bugs are fixed and new features are added.

• Various publications were written, including a 245 page Users Manual, a third-party Interfacing Guide, and chapters in two books on watershed modeling. Work continues on producing a complete Reference Guide that describes all of the theory behind the SWMM algorithms and provides guidance on how to use the program to model various scenarios.

Related Tools Development Using SWMM

Two computer tools are being developed that utilize SWMM's runoff and sewer routing modules. The System for Urban Stormwater Treatment and Analysis (SUSTA) is a decision support framework for evaluation and placement of BMPs in urban watersheds. It uses the SWMM routines to perform landscape rainfall-runoff simulation and flow and pollutant routing through conduit and an open channels. SUSTA will help develop, evaluate, select, and place BMPs based on cost and effectiveness.

The Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox analyzes the impact that rainfall derived infiltration and inflow (RDII) has on capacity analysis of sanitary sewer systems. The Toolbox uses SWMM to perform dynamic flow routing through a sewer network system and uses the graphic utility interface capability in SWMM to visualize sewer system responses and export output data for further analysis.

Research Conclusions & Future Directions

Professor Wayne Huber of Oregon State University, one of the original developers of SWMM, has remarked that "EPA's redevelopment of SWMM makes this powerful program more accessible to a new generation of hydrologists and engineers, has produced a foundation that can produce future advancements in stormwater modeling, and underscores EPA's commitment to maintain its leadership role in providing open source computing tools to the stormwater management community."

NRMRL plans to build upon the current SWMM redevelopment effort by adding better support for modeling BMP/LID alternatives and for modeling sediment washoff and transport.

Interactions with Customers

The updated SWMM model has been downloaded by hundreds of users around the world. Its computational engine has been incorporated into several commercial modeling packages. It is being used by consulting engineering companies on high visibility projects in Cincinnati, Pittsburgh, and Philadelphia. The Denver Urban Drainage and Flood Control District has updated their planning tools to interface with the new SWMM. EPA regions are sponsoring its use in CSO/SSO control studies. It is also being used in several ongoing NRMRL research projects involved with BMP placement and planning issues.

How Research Contributes to Outcomes

SWMM is used by hundreds of governmental agencies and consulting engineering companies to analyze, plan, and design systems and policies for controlling stormwater runoff and combined sewer overflows. These activities directly impact the Agency's TMDL, NPDES Permitting, CSO/SSO, and CMOM programs as they support efforts to protect and restore vulnerable aquatic systems.